Manufacturing of Blended Cement

Summary

The additive components of blended cements (or masonry cements) are mostly ground together with clinker in a tube mill (compound grinding). The product specifications (fineness, homogeneity) can thus be fulfilled without major problems. Disadvantages are high power consumption and limited drying capacity within the mill.

To overcome these disadvantages the additive components can be ground separately with subsequent proportioning and blending of the components. Grinding as well as drying represents no problem. However, attention has to be paid to the selection of the proportioning devices and the blending procedures to meet the standard specifications.

Small capacities are often produced in compound grinding whereas separate grinding should be preferred for large capacities.

1. INTRODUCTION

Prior to any manufacturing of blended cements a detailed investigation of the components to be blended with cement is mandatory.

Figure 1 Manufacturing of Blended Cement and Masonry Cement

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MATERIAL INVESTIGATION		PROCESS SELECTION
⇒ Suitability of component ⇒ Mix ratio etc.	⇒	⇒ Grinding system ⇒ Drying system etc.

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Target:
PRODUCTION OF HOMOGENEOUS CEMENT WITH ADEQUATE QUALITY AT LOWEST PRODUCTION COSTS

The material investigations shall give some indications with regard to the suitability and the possible mix ratio of the additive component. These results and further evaluations of the properties of the additive component and the final product shall serve as a basis for the process selection. The material and process investigations have the same common target:

'Production of a homogenous cement with an adequate quality at lowest production costs.'

2. PROCESS TECHNOLOGICAL PROPERTIES

The main task of the manufacturing of blended cement is to replace clinker by other hydraulic active materials.

Figure 2 Process Technological Properties of Blended Cement and Masonry Cement

Type of cement	BLENDED CEMENT			MASONRY CEMENT
Type of blend component	Synthetic pozzolan		Natural pozzolan	Limestone Dolomite Marl Raw meal etc.
	Slag	Fly ash	Pozzolan Tuff etc.	
Chemical properties	same as Portland-cement			qualitatively not comparable
Mix. proport. (%)	20 - 70	10 - 30	10 - 30	30 - 70
Grindability (kWh/t)	30 - 40	5 - 20	20 - 30	5 - 30
Moisture cont. (% H_2O)	0 - 20	0 - 35	5 - 15	0 - 20
Process aspects	directly ground and dried without further preparation		exploitation and/or crushing prior to grinding - drying required	

Hydraulic active materials are synthetic pozzolan (such as slag and fly ash) and natural pozzolan. From the material technological point of view a strict difference has to be made between blended cements and the so called masonry cements. The chemical properties of blended cements are comparable to those of ordinary Portland cement whereas masonry cements have due to their quite specific application not the same product properties.

As far as the process technological aspects are concerned the additive components used for the blended cements and masonry cements can be subdivided into materials which can without further preparation directly be ground to blended cements and into materials which require prior to grinding a further processing such as exploitation and/or crushing. The first group includes the cements containing industrial by-products such as slag cement and fly ash cement whereas the second group includes the pozzolan cement and masonry cement.

Nevertheless, the manufacturing processes of both blended cements and masonry cement are basically connected with the same problems; i.e. the relevant process technology know-how of blended cements are within some limits also valid for the masonry cement preparation.

3. MANUFACTURING POSSIBILITIES

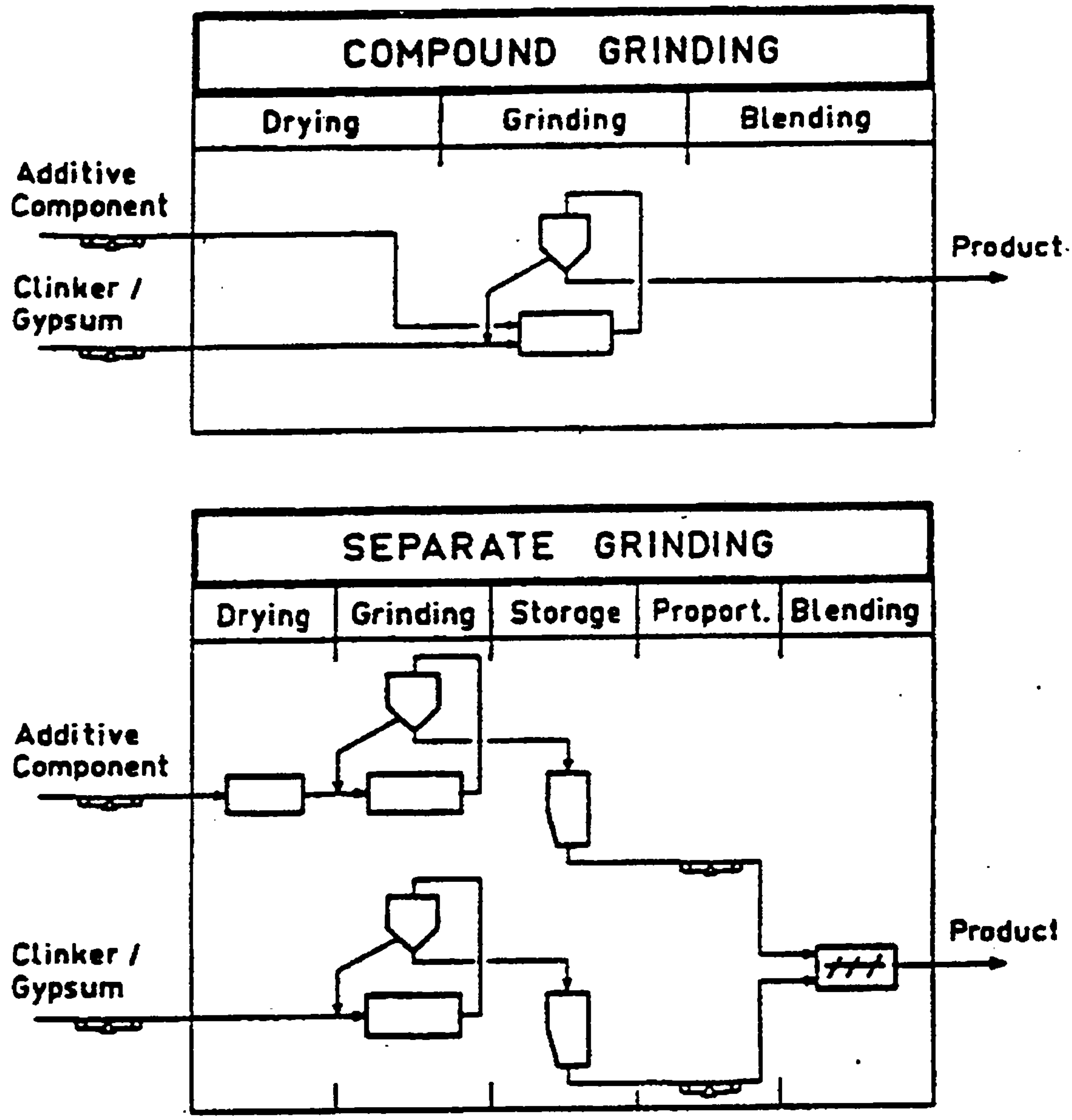
3.1 General

As it can be concluded from the rather different properties of the additive components there seems to be a large number of possible manufacturing possibilities.

It is not the target of this presentation to describe the alternatives in every detail but to summarize the outcome of an evaluation of a questionnaire concerning the manufacturing of blended cements. Considering these plant experience and furthermore taking into account the result of different laboratory tests carried out at HMC/TC the manufacturing of blended cements can roughly be subdivided into two methods; which are

- compound grinding of the additive components in one mill and
- separate grinding of both, the additive component and the clinker with subsequent blending

Figure 3 Manufacturing Possibilities for Blended and Masonry Cement



In the compound grinding method the components are ground and blended in one single piece of equipment. Depending on the moisture content of the additive component often also drying can be effected in the mill. Most of the blended cements and masonry cements in the "Holderbank" Group plants are produced by compound grinding.

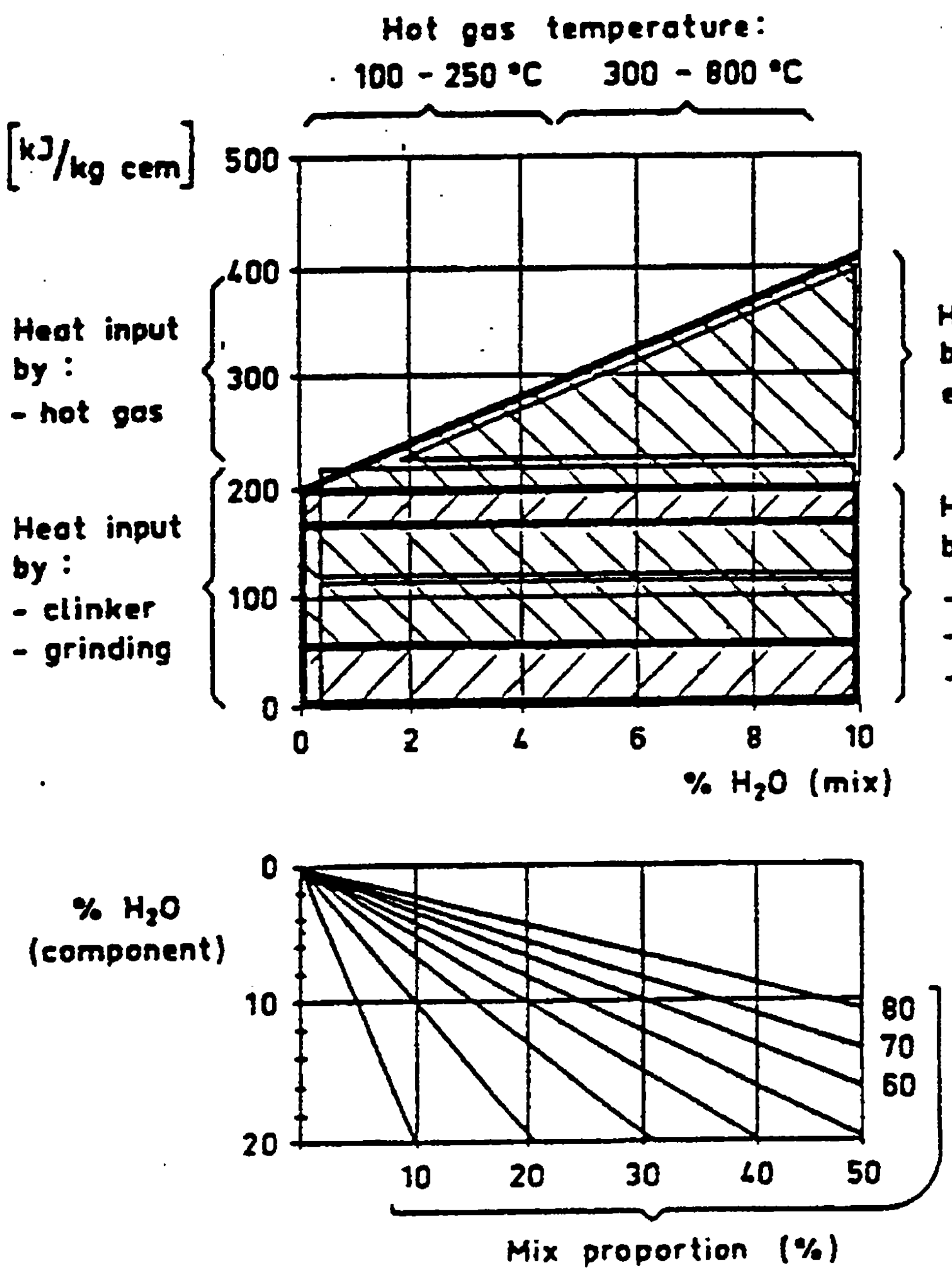
If the additive components have a very different grindability as compared to clinker or in case of elevated moisture contents of the component a separate grinding is often more advantageous. The component can either be dried separately or it can be dried in a grinding-cum-drying system. Separate grinding requires in addition to the grinding and the drying system also intermediate storage, proportioning and blending facilities. Considering the larger number of equipment required in case of separate grinding, this method is often only feasible if large quantities of blended cements or masonry cements have to be produced.

Each process step as well as the selection of the relevant equipment has to be carefully evaluated by due consideration of the prevailing properties of the additive components and the required product specifications. The most important criteria concerning drying, grinding, storage, proportioning and blending are dealt with in the following chapters.

3.2 Drying

Most of the additive components have a high moisture content so that they have to be dried. The decision whether the component can be dried inside the mill or if a separate drying plant is required depends basically on the prevailing moisture content and the mix ratio of the additive component. To judge the limits of drying inside a mill a heat balance has to be elaborated.

Figure 4 Drying-cum-Grinding of Blended Cement



The simplified heat balance as shown in figure 4 is based on the following assumptions:

- Grindability of clinker and additive component more or less identical

- Clinker temperature: 130 - 140 ° C
- Cement temperature: 100 ° C
- Mill exit air temperature: 90 ° C
- Air speed inside mill: 2 m/s

The heat balance assumes that the heat output by radiation, convection, cement and mill exhaust air remains constant independent of the relevant moisture content of the mixture. The heat output by evaporation is in turn directly related to the moisture content.

As it can be seen in figure 4 the total heat required for drying is only partially covered by the heat input by hot clinker and by grinding heat; i.e. the additional heat has to be provided by hot gases.

For a moisture content of the mixture of up to 4.0 % a hot gas temperature of 100 - 250 ° C is required. The hot gases can (if available) taken from a grate cooler. At a higher moisture content of the mixture the required hot gas has to be supplied by an auxiliary furnace with a temperature in a range of 300 - 800 ° C. Due to the potential risk of dehydration of the gypsum at these elevated temperatures a drying of the component in the mill is therefore in such a case often not recommendable.

If a substitution of the gypsum by anhydrite is not possible there are basically two possibilities to avoid the risk of dehydration; reduce the mix proportion to such a level that a low drying gas temperature is sufficient or separate drying of the additive component outside of the mill. Whether the first or second measure should be applied depends on the investment costs of a separate drying plant compared with the increase of the production costs due to an increase of the portion of clinker to be used.

If no hot gases at all and no separate drying facilities are available the mix proportion has consequently to be reduced to maintain a moisture content of the mixture which can be dried in the mill by the clinker heat and by the grinding heat only.

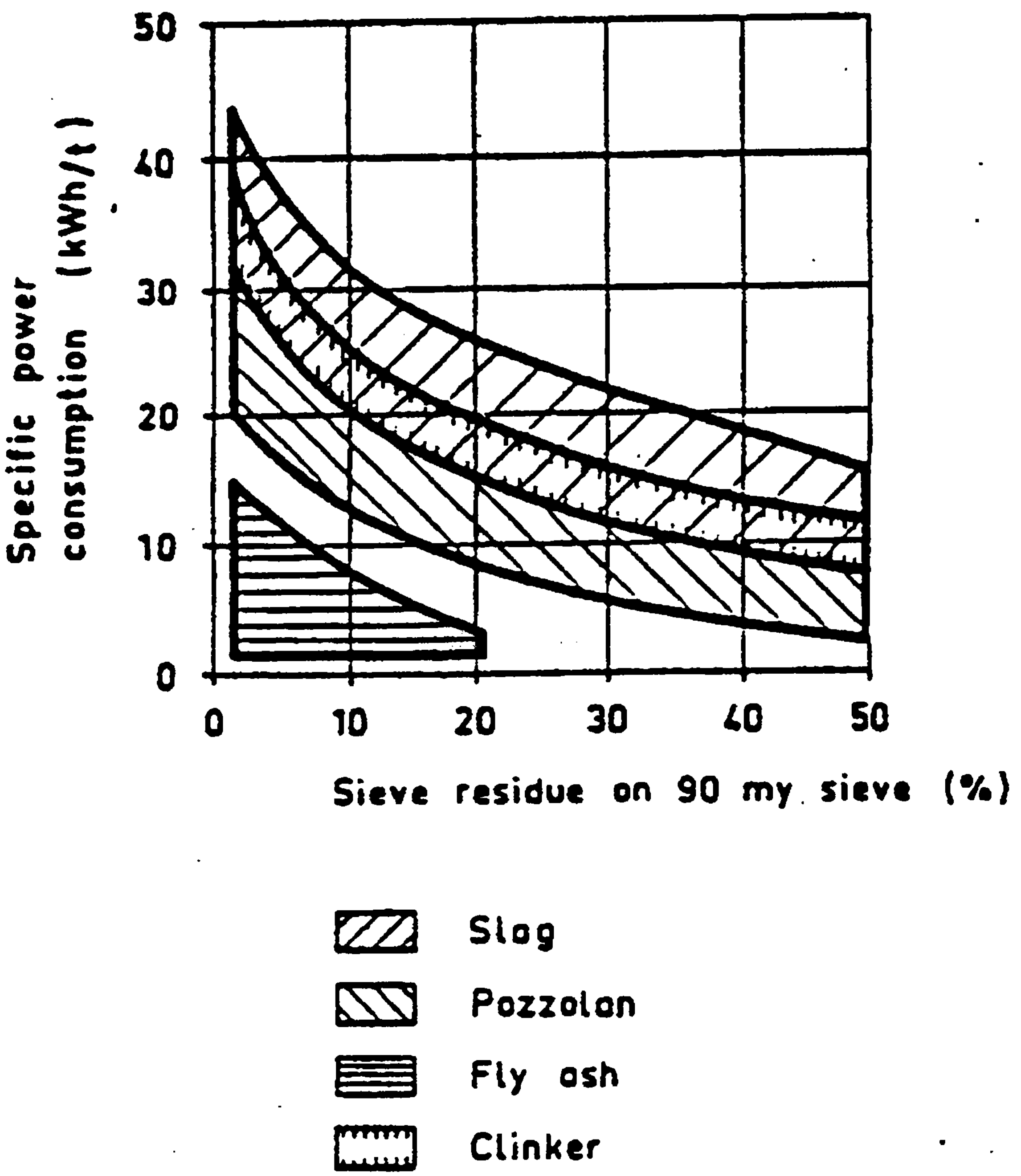
It is obvious that the conclusions as derived from figure 4 can not directly be transferred to every type of blended cement manufacturing. A heat balance has to be established for each case taking into account the relevant material properties as well as type and size of the mill equipment.

3.3 Grinding

The grindability of the individual components is of great importance for the decision which type of mill and which preparation system has to be selected.

The evaluation of the grindability tests are carried out at the HMC/TC laboratories shows considerable differences between the grindability of the individual components (figure 5).

Figure 5 **Specific Power Consumption (Test Mill) of Mix Components of Blended Cement**



Slag shows as compared with clinker generally a poorer grindability whereas the pozzolan shows a better grindability than the clinker. The grindability of the fly ash can be judged as very good.

The grindability of the additive component alone is, however, not a definite indication about the reaction in the mill when they are ground together with clinker. No specific grinding problems have to be expected, if the grindability of the slag or of the pozzolan is in the same order of magnitude as the clinker. As soon as the grindability of the additive component is very different from the clinker an overgrinding of the easier grindable component has to be expected. This could lead to disturbances of the grinding operation and therefore result in a capacity drop and in an increase of the specific power consumption.

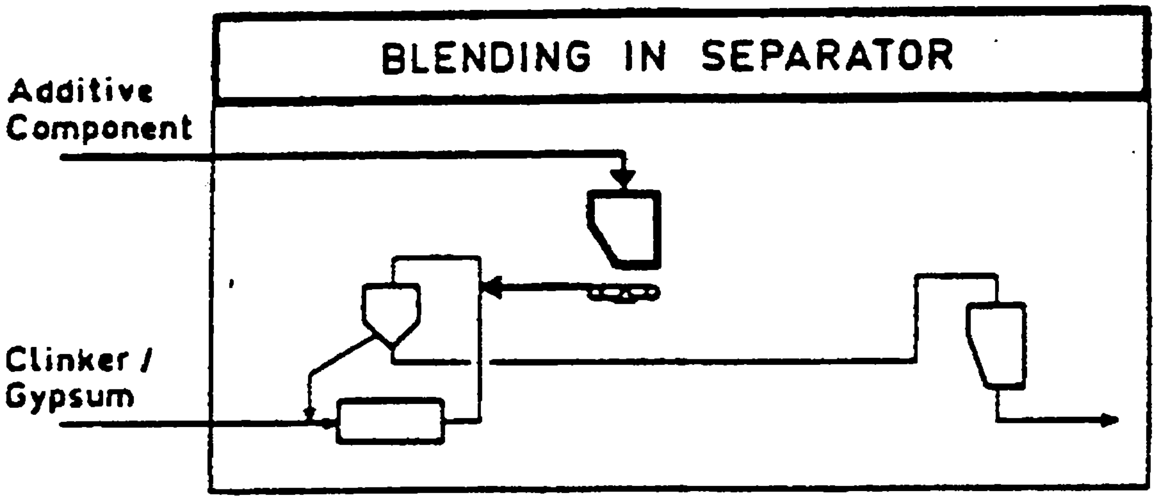
To avoid these disadvantages it is often recommended to grind components with widely differing grindabililty in two separate mills. The ball charge composition of each mill could in this case be optimally adjusted to the relevant additive component.

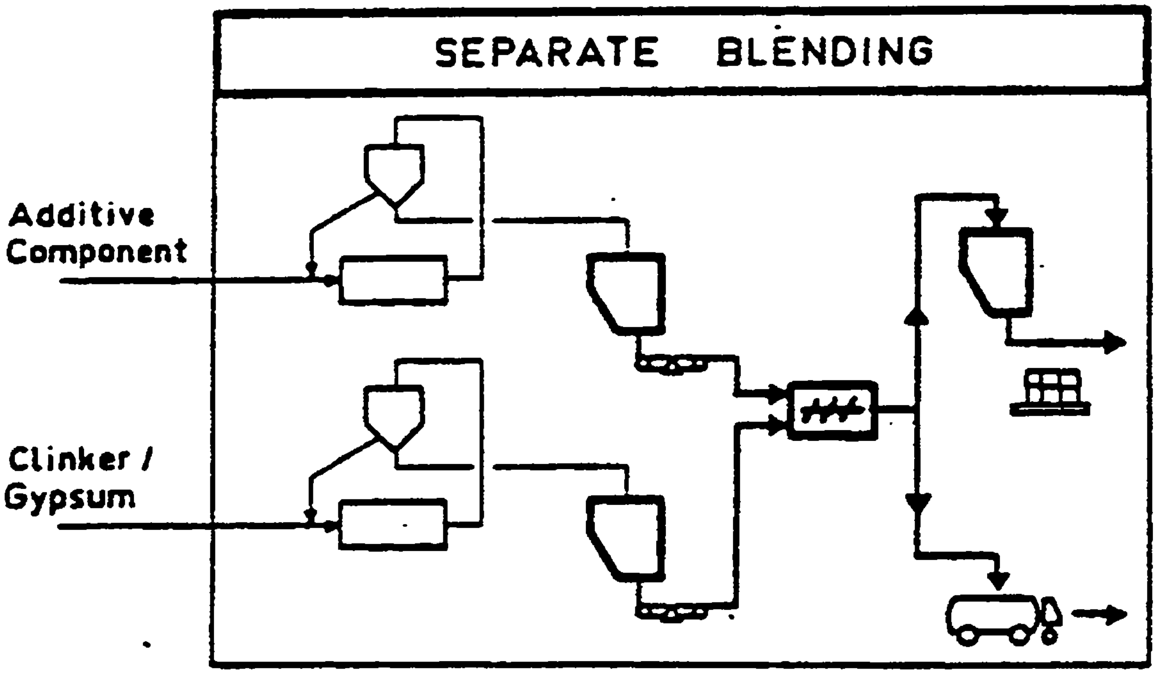
Fly ashes are due to their very fine granulometry not directly interground with the clinker but they are fed to the separator. The coarse particles of the fly ash are recirculated to the mill whereas the fine fraction is going into the final product. The coarse fraction of the fly ash acts depending on its carbon content also as a grinding aid; i.e. with the addition of fly ashes the mill output can often be increased.

3.4 Storage, Proportioning and Blending

If the additive component is supplied in a very fine granulometry (e.g. fly ash) or in case of separate grinding, the component is very often fed to the separator where it is blended with the cement.

Figure 6 Storage, Proportioning and Blending of Blended Cement





Experience has shown that for a mix proportion of the additive of up to 30 % no overload of the separator has to be expected.

If the portion of the additive component is higher than 30 % the blending of the component has to be carried out in separate blending devices, such as forced mixers, mix screws, homogenizing silos, etc.

For a separate blending of the components, they have to be stored in intermediate storage silos. The flow properties of the dried and ground materials lead often to the risk of uncontrolled material rushes and discharge problems.

To prevent material bridges or to avoid a piping effect where only material in the middle is discharged it is advantageous to design the silos for mass-flow.

As far as the proportioning of the components is concerned it has to be emphasized that an adequate proportioning is much more important than the subsequent blending process. The best blending device is not able to compensate proportioning errors.

For small quantities volumetric feeders such as rotary feeders and proportioning screws are often sufficient. If a high feeding accuracy is required it is recommendable to install gravimetric feeders such as weigh feeders or impact flow meters.

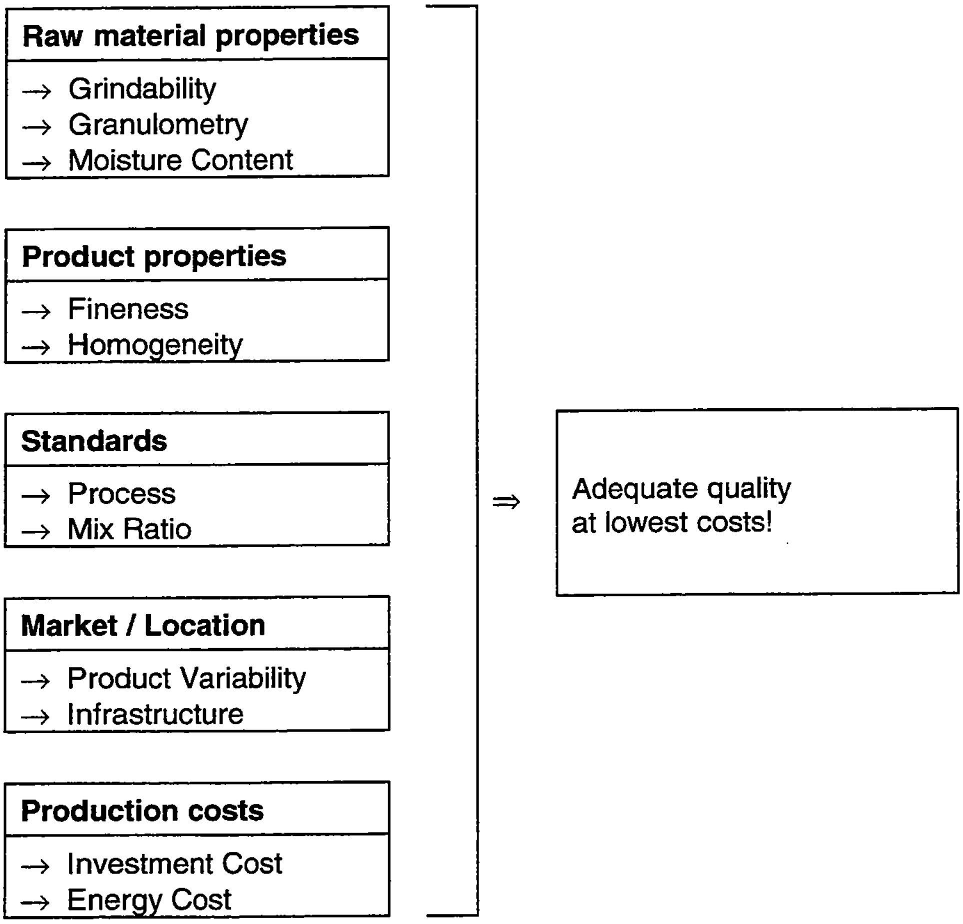
Depending on the local conditions either batch blending or continuous blending is used. Batch blending can for example be used where the blended cement is loaded directly into bulk carrier vehicles. Both blending methods can be used if the blended cements are stored in silos.

4. FURTHER SELECTION CRITERIA

As mentioned previously the selection of the grinding, drying and blending method is principally dictated by the raw material properties and the product specifications.

Further to these process technological criteria, however, also the relevant standards and regulations, the market situation, the plant location and last but not least also the production costs have to be considered.

Figure 7 Compilation of Process Selection Criteria



In some countries there are standards which specify the manufacturing of blended cements by compound grinding only.

If there are several customers who want different compositions of blended cements this demand can often only be satisfied by separate grinding and separate storage of the components.

The location of the cement plant and the location of the available additive component is of course also of influence for the selection of the preparation system. It is quite possible that the two locations to be far apart so that the individual components can for transport reasons only be transported whey they are already ground, which means that the components would have to be ground separately.

If the blended cement accounts for only a small percentage of the total production of the grinding system the blended cement can often be manufactured by compound grinding of the components in an existing mill. Any higher costs of production incurred in this way in comparison to separate grinding are almost negligible.

On the other hand, if it is intended to change over production from Portland cement to blended cement, or if the blended cement accounts for a very high percentage of the total production, it is absolutely essential for a change in the grinding system to be studied in detail so as to ascertain both, the cost of production and the level of investment and to compare them.

When design work is being carried out for a new grinding system all aspects that have been referred to so far, must be looked into in detail to ascertain an adequate quality at lowest costs!

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